PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Method and Apparatus for Forming Tenacious Deposits on a Surface

We, ION PHYSICS CORPORATION, a Corporation organized under the laws of the State of Delaware, United States of America, of South Bedford Street, Burlington, State of Massachusetts, United States of America, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

This invention relates to the formation of tenacious solid deposits in such forms as films, coatings or spots on a solid substrate surface.

Forming deposits of one material on the surface of another has many purposes, such as the formation of thin films for protective purposes; in the manufacture of capacitors, coated lenses; in the formation of passivating layers for semi-conductor devices; for establishing contact to make electrical connection or simply to join one material to another. Numerous of the available techniques are unsuitable for many purposes, such as chemical methods making use of solvents or electrolytes that would affect the surface to be coated, or methods requiring temperatures which one or the other of the materials can not tolerate. A further trouble in many cases arises when the substrate to receive the deposit and/or the material to be deposited are of such nature that a strong bond is not easily established.

The present invention provides for the formation of a deposit of material which is highly tenacious, generally quite independently of the nature of the two materials, such that strongly adherent contact may be made between them and thin continuous films of one solid may be applied to another.

In the process of this invention the material is transferred from a target source to the recipient substrate surface at high energies (5—50 KEV or more) and at low temperatures. Strongly adherent deposits may be built-up under conditions which do not adversely affect either material.

According to the invention there is provided a method of forming a tenacious deposit of a solid material on a solid substrate surface comprising the steps of generating a plasma of inert gas, extracting a beam of ions or neutral atoms from said plasma, directing said beam of ions or neutral atoms at a target surface of said solid material at an energy sufficient to remove from the target particles of said solid material, placing said substrate surface in the path of said removed particles, and passing said beam through a maintained ambient pressure of less than 10^{-5} Torr.

By inclining the target surface to the ion beam the particles may be diverted to the side and deposited on a substrate surface located close by.

The process differs from known sputtering techniques which require an appreciable pressure to provide an ionizable atmosphere in which emission of cathode material will take place. Material which is sputtered conventionally encounters many collisions with gas molecules in its path and does not strike the recipient surface at maximum energy, nor at right angles except by chance.

In the process of this invention all of the material removed from the target by the ion beam travels directly to the substrate surface. Because of the high vacuum few, if any, collisions with other particles are encountered,

is controlled by adjusting the several voltages in well known manner.

Within the chamber and close by the path of the beam is mounted a heated filament 37, e.g., of tantalum, which may be operated to neutralize the beam and prevent the accumulation of a charge on targets of dielectric material.

Additional control over the beam is provided by mounting a target aperture 40, preferably made of material the same as the target, just in front of the target. This serves to protect the substrate material from ion bombardment, and further narrows the beam striking the target.

In a typical operation the housing is evacuated to a pressure less than 5×10^{-6} Torr, and the argon ion beam is accelerated to an energy level of 30 KEV, and focused through the aperture 40, having a diameter of 1.6 centimeter. A narrow beam of several milliamperes is thereby caused to strike the surface of the target 14, which is inclined to the beam at an angle α of 30 to 60°, preferably 45°. The substrate 18 to be coated is mounted parallel to the target about 5 centimeters away.

The rates at which various materials have been found to deposit are given in the following table:

A+ at 30 KEV, a=45°, L=5cm, ϕ=1.6cm

Carbon	46	A/Minute/Milliampere
Aluminum	140	" "
Silicon Carbide	32	" "
Titanium	57	" "
Silicon Dioxide	44	" "
Titanium Dioxide	14	" "
Tantalum	45	" "
Tungsten	31	" "

Various films have been applied to different substrate materials including glass, "Mylar" and various metals. The word "Mylar" is a registered Trade Mark. It was noted that when either silicon or carbon was applied to a "Mylar" base, they adhered with such great tenacity and strength that the films could be wrinkled severely with negligible effect on the physical or electrical characteristics of the film.

The application of a silicon dioxide film to a metal base followed by the application of a metal film provided a capacitor having a dielectric strength of about 5×10^6 volts per centimeter and a dielectric constant as high as 4.73.

A characteristic of the process is the ability to deposit materials of extremely high purity. For instance, fused quartz may be applied by this process to the surface of a semi-conductor to form a passivating layer.

Although this invention has been described in detail with reference to the presently preferred embodiments, it is contemplated that modifications will occur to those skilled in the art and familiar with the principles herein disclosed, and that such modifications may be made without departing from the scope of the invention. In addition, while the invention is generally described as utilizing a beam of ions of an inert gas, it should be noted that the effect of the neutralizing filament 37 is to add electrons to the positively charged ion beam, to neutralize it, through the formation of atom particles which then strike the target. The formation of ions is necessary for electrostatic acceleration, but for bombardment purposes it is immaterial whether the particles are charged ions or neutral atoms.

WHAT WE CLAIM IS:—

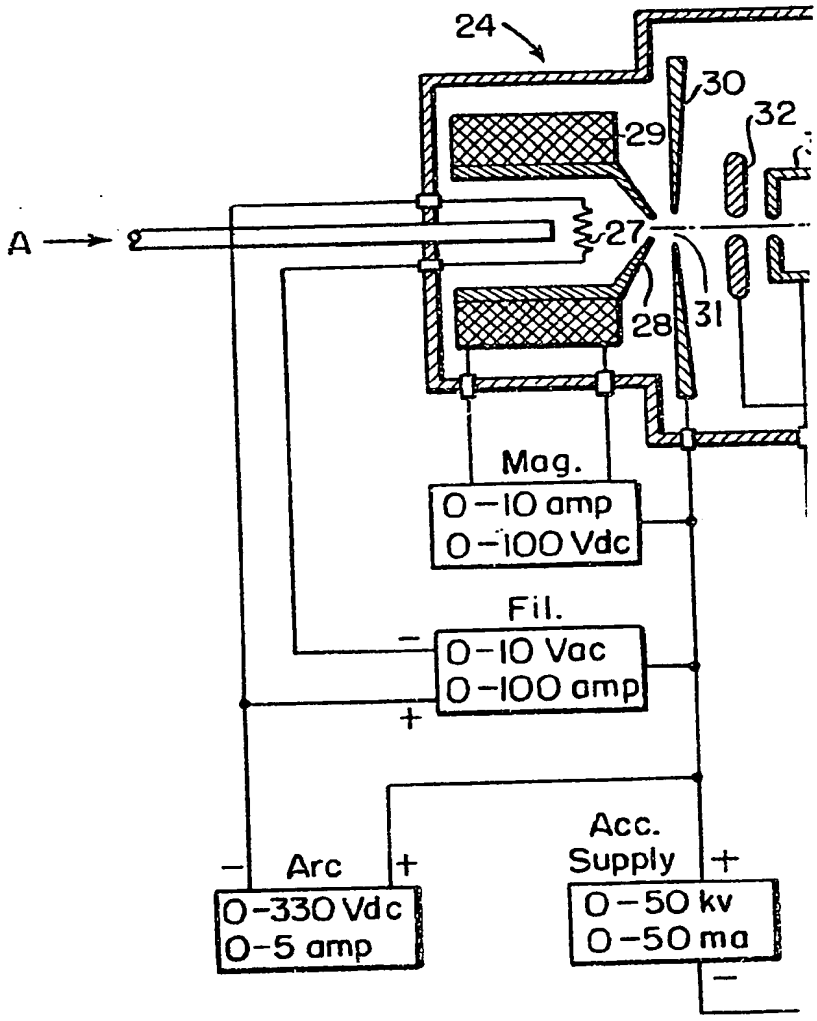
1. A method of forming a tenacious deposit of a solid material on a solid substrate surface comprising the steps of generating a plasma of inert gas, extracting a beam of ions or neutral atoms from said plasma, directing said beam of ions or neutral atoms at a target surface of said solid material at an energy sufficient to remove from the target particles of said solid material, placing said substrate surface in the path of said removed particles, and passing said beam through a maintained ambient pressure of less than 10^{-5} Torr.

2. The method according to claim 1, wherein said ion beam is formed by ionizing said inert gas and placing said target at an angle relative to the direction of the beam in the path of said beam and locating said substrate surface spaced from the exposed surface of the target in the path of said particles.

3. The method according to claim 1 or 2, wherein said ion beam is accelerated to an energy of 5 KEV to 50 KEV.

4. The method according to any one of claims 1 to 3, comprising the intermediate step of neutralizing said ion beam to discharge the ions and form atoms from said ions which atoms strike the target.

5. The method according to any one of claims 1 to 4, wherein the inert gas is argon or xenon or krypton.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Mag.
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0–330 Vdc
0–5 amp
Acc.
Supply
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1 SHEET This drawing is a reproduction of the Original on a reduced scale.